Incorporating Temporal and Clinical Reasoning in a New Measure of Continuity of Care

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Previously described quantitative methods for measuring continuity of care have assumed that perfect continuity exists when a patient sees only one provider, regardless of the temporal pattern and clinical context of the visits. This paper describes an implementation of a new operational model of continuity—the Temporal Continuity Index—that takes into account time intervals between well visits in a pediatric residency continuity clinic. Ideal continuity in this model is achieved when intervals between visits are appropriate based on the age of the patient and clinical context of the encounters. The fundamental concept in this model is the expectation interval, which contains the length of the maximum ideal follow-up interval for a visit and the maximum follow-up interval. This paper describes an initial implementation of the TCI model and compares TCI calculations to previous quantitative methods and proposes its use as part of the assessment of resident education in outpatient settings.

INTRODUCTION

Continuity of medical care has been operationally defined as "the extent to which the same provider is seen during a sequence of visits" [1]. Previously described quantitative methods for measuring continuity of care have assumed that perfect continuity exists when a patient sees only one provider, regardless of the temporal pattern and clinical context of the visits; but even a patient who sees the same provider 100% of the time may have poor continuity if the visits are inappropriately timed. This paper describes an implementation of a new operational model of continuity that takes into account some temporal and clinical factors and applies it in measuring continuity of care for well visits in a pediatric residency continuity clinic.

Continuity of care is an essential component of primary care [2]. Patients consider continuity an important determinant of the quality of their health care [3, 4], and health care providers regard continuous care as the ideal [2, 5, 6]. Evidence exists from outcomes studies that health care delivery systems which allow continuity result in lower health care costs [7, 8], more efficient identification of problems [9], better compliance with drug regimens and appointments [10-13], and improved job satisfaction of health care workers [11, 12, 14]. Medical educators consider continuity of care to be an essential, albeit elusive, goal in outpatient medical education [15-17] since continuous care provides students and residents with a more complete picture of the natural history of disease and well care. An objective measure of continuity of care would be of great use to medical educators as they attempt to ensure high quality educational experiences in increasingly outpatient-oriented training programs.

Traditional measures of continuity of care, which have been reviewed elsewhere, have considered continuity from the point of view of a patient, a visit, or a provider [3, 18, 19]. The most frequently used patient-based measure, Usual Provider Continuity (UPC [20]) is the ratio of the number of visits to a patient's "usual" provider to the total number of visits for that patient. A patient-based measure that uses temporal information is Sequential Continuity (SECON [18]), which views a series of clinical encounters as pairs of consecutive visits; SECON is the ratio of the number of pairs with the same provider to the total number of pairs. Visit-based measures compute continuity based on the visits that occurred during a fixed interval prior to the visit in question. A visit-based measure that uses temporal information is *discounted fraction-of-care continuity* (f_τ) [21]. f_τ is a modification of UPC which uses weights based on how recent a previous visit is relative to the present visit. This measure is said to be visit-based because it assigns a number to a visit; one computes a score for the patient by combining all of the patient's visit scores. Provider-based methods combine the results from patient-based or visit-based methods for each provider. Implicit in all these measures is an assumption that one provider per patient represents perfect continuity.

While measures like SECON and f_τ take some temporal aspects of continuity into account, no continuity measure takes clinical context into account. For example, if a patient sees a physician for two well visits spaced nine months apart, the continuity that this pattern of visits represents can be good or bad, depending on the patient's age and clinical problems. If the initial visit was for a newborn, then this pattern represents poor continuity. If the initial visit was for a two year old, then a nine-month interval may represent good continuity.

Hoekelman and Peters [22] modified the Well Baby Visit index of Barron and Mindlin [23] to create a Health Supervision Index (HSI) that could be applied to a pattern of well visits in the first two years of life. This measure divides the first two years of life into periods during which at least one well visit must occur. For the first six months of life, the periods are one month long; during the second six months, two months; and for the second year of life, three months. This partitioning of the first two years corresponded to the prevalent American Academy of Pediatrics recommendations [24] at the time. While HSI addresses the temporal nature of a certain kind of medical care, it is not generally applicable to all ages and clinical problems.

TEMPORAL CONTINUITY INDEX

Assumptions

In the Temporal Continuity Index (TCI) model, it is assumed that there is an ideal interval between visits and that continuity decreases and eventually vanishes altogether as this ideal interval is exceeded. Thus, to achieve maximal continuity, it is not enough to see just one provider; ideal continuity in this model is achieved when intervals between visits are appropriate based on the age of the patient and clinical context of the encounters. These intervals vary with the age of the patient and the clinical problems addressed in the visits. In this model, each visit receives a continuity score, the Temporal Continuity Index (TCI_v), between 0 and 1; continuity for patients (TCI_{pt}) and providers (TCI_{pr}) may be computed by averaging the TCI_v for each relevant visit. It is assumed that the primary data represent ambulatory visits between identifiable patients and providers, and that the time for each visit and basic diagnostic coding for each visit is available.

Expectation Intervals and Closing Criteria Model

The fundamental concept in this model is the *expectation interval*, which contains the length of the maximum ideal follow-up interval for a visit (t_i), and the maximum follow-up interval (t_m). Each visit has an expectation interval and a set of closing criteria. *Closing criteria* define which future visits may close a prior visit v_0; for example, only those subsequent visits with diagnoses similar to v_0 may close v_0. If v_0 is closed by a subsequent visit before t_i, maximal continuity for that visit is achieved. If it is closed between t_i and t_m, then v_0 receives a continuity score less than maximal, depending on the position of the closing visit within the interval. Closing visits after t_m result in a minimal continuity score for the visit. Each time a visit is recorded, (whether it closes another visit's interval or not) its expectation interval is computed and attached to the visit. The model intentionally omits the concept of the minimal ideal follow-up interval, since to specify a minimal interval would tend to penalize providers for seeing a patient earlier than expected.

Figure 1 illustrates a visit which is associated with an expectation interval and a set of closing criteria. Closing visits (visits which meet the closing criteria) must occur before t_m or the expectation interval will time out spontaneously, which results in a TCI_v of 0 for the visit. The linear taper between t_i and t_m represents the decreasing continuity if a closing visit occurs between t_i and t_m. In most situations, closing visits must involve the same provider; this need not be the case, however: for instance, one may want to allow different providers but require they be in the same practice group.

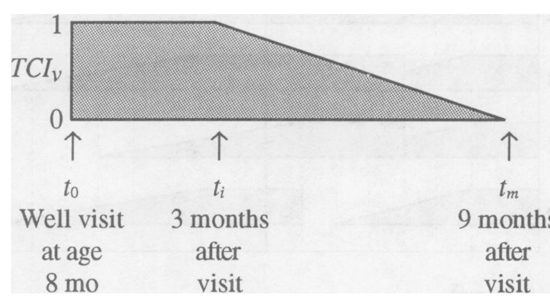

Figure 1: Expectation interval for a visit. For this well visit in an eight-month old, t_i is 3 months and t_m is 9 months after the visit.

Clinical Reasoning

The length of expectation intervals vary with the clinical problem. Age of the patient at a well visit affects expectation intervals; follow-up for well care in a teenager allows much longer intervals than follow-up for well care in infants. Diagnoses at non-well visits would also affect expectation intervals; for example, follow-up for tinea capitis is of longer duration than for an asthma exacerbation, because the natural history of one disease episode is longer than the other.

Not all visits require follow-up, so lack of a follow-up visit for certain types of visits need not imply a penalty for the provider's continuity score. For instance, most acute illnesses resolve without complications, so no closing visit is necessary. Well visits, on the other hand, are expected to be followed by an appropriately timed follow-up well visit. Thus, well visits are classified as *penalty visits*; there is a penalty to the continuity score if there is no follow-up of these visits. Visits associated with other diagnoses may be penalty visits depending on the clinical context. In the TCI model, the TCI_v of a penalty visit is included in the average for the provider whether it is zero or non-zero. The TCI_v of non-penalty visits is omitted from the computation of TCI_{pr} if it is zero.

The specification of closing criteria requires clinical knowledge to determine which visits close which others. An visit may close a prior well visit if it involved the same patient, the same physician, and is itself a well visit. For other diagnoses, these criteria may be more complex.

Figure 2 illustrates the pattern of visits for four patients over eight months. TCI computations for patients A, B, and C are shown in Table 2.

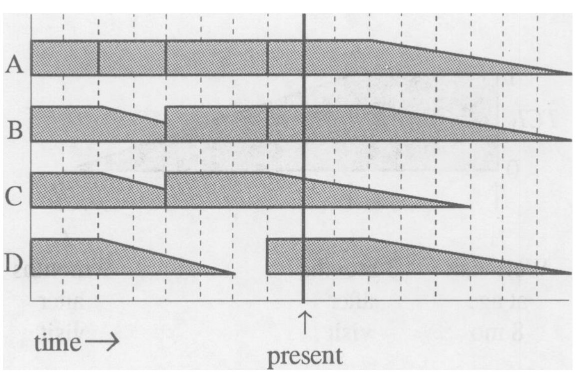

Figure 2: Pattern of visits for four patients. Patient A has ideal intervals among the four visits and thus has maximal continuity. Patients B, C, and D have progressively worse continuity, since the expectation interval between visits is closed after the magnitude of TCI_v begins to taper.

IMPLEMENTATION OF THE MODEL

Program Design

A program was written in the Common Lisp Object System (Macintosh Common Lisp, Apple Computer, Cupertino, CA) to store residents' experience data and to perform continuity of care calculations according to the Temporal Continuity Index model. Relational tables from the Resident Group Practice continuity clinic database (patient identifiers, resident identifiers, and diagnostic data) in the Department of Pediatrics at Washington University School of Medicine were used as input to construct objects in three classes (resident, patient, and visit). Since the objective of this program was to provide an index of continuity for each resident, the program did not produce continuity scores for each patient.

Resident Object

Resident objects contain an identifier and an indicator of the resident's level of training. To each resident object is attached two lists of visit objects: a *pending* visit list and a *final* visit list. New visits enter the pending list to await closure. As soon as all possible closing visits have occurred (if any), the visit is moved to the final list. The final list contains visits which have been closed by another visit or which have spontaneously timed out because no closing visit occurred. The chief reason for maintaining two separate lists is to decrease the number of visits to consider closing each time a new visit enters the system.

Patient Object

The patient object contains patient identifiers, demographic information, and a list of diagnoses with which the patient has been associated.

Visit Object

Each visit object carries identifiers for the relevant resident and a patient, along with the date, diagnosis codes, state of the visit (open or closed), closing criteria, closing penalty (to indicate whether there is a penalty for not explicitly closing the visit), and the expectation intervals t_i and t_m. The visit also holds the maximum TCI_v for the visit. The state of the visit (open or closed) refers to the absence or presence of a closing visit, respectively; a closed visit may stay on the resident's open list until the possibility of out-of-order entry of further closing visits has passed.

Derivation of Expectation Intervals

The American Academy of Pediatrics publication *Guidelines for Health Supervision II* [25] was used to establish the best times at which children should be seen by their primary care provider for health supervision. Based on these times, maximal ideal time intervals for a follow-up well visit (t_i) were established for each age range (Table 1). The breakpoint for each age range is the midpoint of the interval between the last two ages recommended by the AAP guidelines for the corresponding ideal follow-up interval. Maximum meaningful follow-up intervals (t_m) were established for each age range by multiplying the ideal interval by three.

Derivation of Closing Criteria

In this implementation a closing visit for a well visit was defined as another well visit of the same patient to the same physician within the appropriate time interval. Visits for acute illnesses did not count as closing visits for well visits.

Computing TCI for a Provider (TCI_{pr})

TCI_{pr} for each resident is taken as the mean TCI_v for each visit associated with that resident for which TCI_v can be calculated. From the pending list, only those visits for which a TCI_v have been computed are used to calculate the mean. From the final list, all visits except non-penalty visits with TCI_v of zero are used to compute the mean.

Table 1: Follow-up intervals for well care based on AAP guidelines. Current AAP guidelines recommend a newborn visit, a visit at 2-4 weeks, and visits at 2, 4, 6, 9, 12, 15, and 18 months, followed by an annual visit until age 6 and then every two years until adulthood.

Age Ranges	Ideal Follow-up Interval (t_i)	Maximum Follow-up Interval (t_m)
0-5 mo	2 mo	6 mo
5-16.5 mo	3 mo	9 mo
16.5-21 mo	6 mo	18 mo
21 mo-5.5 yr	1 yr	3 yr
≥ 5.5 yr	2 yr	6 yr

Table 2: Continuity calculations involving three patients with different patterns of well care. Computations are as of 11/1/94. Patient A has the optimal pattern of well care. f_τ (discounted fraction of continuity) and SECON (sequential continuity) are included for comparison to TCI scores.

Patient	M.D.	Visit	Date	Patient Age	TCI Computation				f_τ score	*SECON* score
					Ideal F/U (t_i)	Max F/U(t_m)	Closed by	TCI_v		
Patient A: Ideal Situation										
A	1	A-1	3/1/94	2 mo	2 mo	6 mo	A-2	1	N/A	N/A
A	1	A-2	5/1/94	4 mo	2 mo	6 mo	A-3	1	1	1
A	1	A-3	7/1/94	6 mo	3 mo	9 mo	A-4	1	1	1
A	1	A-4	10/1/94	9 mo	3 mo	9 mo	N/A	N/A	1	1
Mean for Patient A								1	1	1
Patient B: Missed 4 mo appointment										
B	1	B-1	3/1/94	2 mo	2 mo	6 mo	B-2	0.5	N/A	N/A
B	1	B-2	7/1/94	6 mo	3 mo	9 mo	B-3	1	1	1
B	1	B-3	10/1/94	9 mo	3 mo	9 mo	N/A	N/A	1	1
Mean for Patient B								0.75	1	1
Patient C: Ideal timing, alternating providers										
C	1	C-1	3/1/94	2 mo	2 mo	6 mo	C-3	0.5	N/A	N/A
C	2	C-2	5/1/94	4 mo	2 mo	6 mo	C-4	0.25	0	0
C	1	C-3	7/1/94	6 mo	3 mo	9 mo	N/A	N/A	0.47	0
C	2	C-4	10/1/94	9 mo	3 mo	9 mo	N/A	N/A	0.33	0
Mean for Patient C								0.38	0.27	0
Mean for M.D. 1								0.83	0.73	0.63

COMPARISON TO PREVIOUS METHODS

In Table 2 is a schedule of visits for three patients, which represents the continuity clinic activity for one resident (M.D. 1) from 3/1/94 to 11/1/94. Patients A, B, and C all begin attending the continuity clinic at age 2 months on 3/1/94. Patient A keeps the recommended schedule of appointments. Patient B misses the four-month well visit, and patient C alternates visits between two residents.

The TCI_{pr} for M.D. 1 as of 11/1/94 is the mean of TCI_v for visits A-1, A-2, A-3, B-1, B-2, and C-1. The other visits have not yet closed or are with another physician, so they do not count in the TCI_{pr} calculation yet. So TCI_{pr} is 0.83 for this resident based on these data on 11/1/94. This reflects the less than perfect sequence of visits for the three patients the resident saw. To use UPC to calculate a continuity score for the resident requires calculating UPC for each patient the resident saw and then averaging the values. In this case UPC for patients A and B is 1.0, regardless of the fact that patient B missed an appointment. UPC for patient C is 0.5, since that patient saw the usual provider half the time, so the UPC-based continuity score for the resident is 0.83.Averaging discounted fraction of continuity (f_τ) for the eight visits for which it is possible to compute an f_τ yields a value of 0.73. The problem with patient B remains, though; patient B's continuity was maximal by the f_τ method despite the inadequate temporal pattern of visits. SECON is included in Table 2 to illustrate the problem of underestimating the continuity of a patient who alternates providers.

FUTURE PLANS

The next step in this work on continuity measurement is to extend the TCI score to include clinical visits with illness diagnoses. Work is underway to collect expert opinion from the practicing pediatricians in the Community Outpatient Practice Experience Program on intervals for the most common ambulatory pediatric diagnoses. To handle non-well diagnoses, the model described here will need to take into account visits in which multiple diagnoses are listed. Closing criteria for such visits are more complex, since a follow-up visit may not have diagnostic coding identical to the original visit. Further extensions of the model may also need to consider a *minimal* ideal continuity interval.

Other future work includes the establishment of norms of continuity (TCI_{pr})based on clinical encounter data collected from practicing pediatricians. These norms should allow the use of TCI as a standard for residents in their continuity clinic experience. Ultimately this work will lead to a large scale database implementation of continuity of care measurement in the ongoing pediatric residency program, for which we are now constructing the data model. As residency programs increasingly use outpatient settings for resident education, measures such as the Temporal Continuity Index will help to assure adequate preparation for primary care physicians.

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